XXI.

ATMOSPHERIC ELECTRICITY.

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By direction of the Chief Signal Officer, observations on atmospheric electricity were begun at Harvard College, Cambridge, Mass., under the supervision of Professor John Trowbridge, June 1, 1884.

By permission of the Chief Signal Officer the following abstract is taken from a report upon the apparatus used, and upon the observations from June 1, 1884, to April 30, 1885.

Electrometers.

A Thomson quadrant electrometer No. 26, and a Clifton modification of the Thomson, were originally used. A full description of the former can be found in the British Association Report for 1867, and also among the reprinted papers of Sir Wm. Thomson on "Electrostatics and Magnetism," Paper No. XX. The Clifton instrument is a modified form of the Thomson, designed for greater sensitiveness and of less complicated construction. It is not very generally known, and a brief description of it may therefore be given. The essential parts are four large brass or brass gilded quadrants, supported on glass rods of about 10 cm. length. A bifilar suspension carries an aluminium needle, corrugated and shaped like the figure eight. The length of the suspension is about 15 cm. A platinum wire from the needle dips into a glass vessel containing pure sulphuric acid, and coated on the outside and bottom with tinfoil. In the bottom of the case of the instrument, a circular opening is cut, of diameter sufficient to allow the removal of the glass vessel and the metal base on which it rests. In the upper part of the case is placed a small Thomson replenisher. The air within the case is kept dry by small open glass cups containing sulphuric acid. The needle is charged by means of a platinum wire imbedded in a gutta-percha rod, passing through the side of the case, and dipping into the sulphuric acid.

The instrument, as thus constructed, was found to be extremely sensitive, and admirably adapted to detect the smallest difference of potential of any two bodies, but for a long and continued series of observations, or single experiments of long duration, it was found unserviceable. The electric field of the quadrants was not sufficiently protected from external electrical influences. Two sides of the case only were coated on their interior surfaces with tinfoil, but the theory of the instrument demands, as far as possible, a complete shielding from external electrical influences. The great delicacy of the suspension is possibly the cause of the most serious defect, viz. a shifting of the zero point. The needle would never return exactly to its initial position. The difference was often great enough to give on a scale distant a meter from the mirror, a deflection of a centimeter. In the course of an hour a change in the position of the zero, when all the quadrants were connected, of from two to five or more millimeters would occur. These changes were in part due, no doubt, to a loss in the charge of the needle. To remedy the first defect, new suspending fibres were inserted without effect. To remedy the change due to dissipation of the charge, the vessel jar was paraffined around the edge, and for a time better results were obtained, though still faulty. The glass rods supporting the quadrants were several times taken out, washed with alcohol, dried, paraffined around the edges, and replaced. Other parts of the instrument, in which it was thought the fault might lie, were also carefully cleaned, and where needed provided with better insulation.

To obviate the difficulties met with in using the Clifton, the instrument described in the following sections was designed by Professor Trowbridge, and made at Boston, Mass. It is essentially the Clifton, so modified as to retain its great sensitiveness without having the defects mentioned. It was also desired to have an electrometer of more convenient arrangement than any of the forms now in use, — one in which the different parts should be amply protected from external influences, and yet be easily accessible for examination. The instrument devised has two compartments. In the upper compartment are the quadrants, needle, and suspending apparatus. In the lower compartment is the glass jar, with the arrangement for charging the needle. The upper compartment consists of a wooden case, 25 cm. high and 20 cm. square. On the top and back of the case are tight-fitting brass doors, the one at the top being 12 cm. square, the door at the back being 16 cm. high and 12 cm. wide. When open, these doors allow easy access to the suspending frame, and when shut, form

part of the metallic shield, covering and perfectly protecting the needle and quadrants from external electrical influences and also air currents. Circular brass windows 7 cm. in diameter, encased in brass and inserted in three sides of the case, allow inspection from without, of the needle, and also the passage of the beam of light to and from the mirror.

The bottom of the compartment consists of a brass plate of about 5 mm. thickness. From this plate rise, at alternate corners, two brass rods of 23 cm. height, supporting a cross-beam 20 cm. in length and 5 mm. in diameter. Fastened by a screw to this beam is a cross piece of 3.5 cm. length, supporting two suspending rollers. One roller has a screw movement to or from a central point exactly over the centre of suspension. The end of the roller is enlarged and grooved. One end of the suspending fibre is fastened to the roller by insertion through a small eye-hole in the shaft, and then made to pass in the enlarged groove. The other roller consists of a like brass shaft with an enlarged groove, in which the other end of the suspension fibre runs. This roller has not, however, a screw movement, and turning the screw head in this case simply raises or lowers the needle without change of position of the points of suspension. The whole suspension may be raised or lowered by movement of the screw-head attached to the supporting cross-beam. The plane of suspension may be altered by movement of the cross-bar, which is pivoted on the end of the screw passing through the cross-beam. This suspension is much simpler, equally sensitive with the best arrangements in other instruments, and in case of accident easily repaired. The length of the suspension is about 9 cm. Only one long fibre is employed. The platinum wire carrying the needle is hooked at its upper extremity, and by this means attached to the fibre. The weight of the needle is sufficient to insure a symmetrical suspension, without extra adjustment. If two separate fibres are used, and attached to a small cross-piece on the platinum wire, it will be necessary to test the symmetry of the suspension. The single fibre, however, allows a symmetrical suspension and with the arrangements employed allows easy and accurate adjustment. In the instrument constructed there is no error of position of the zero point. After the greatest deflection when short-circuited, the position of the spot of light on the ground-glass scale is exactly that of its initial position. Six months' constant use of the instrument has not necessitated the use of any correction for the position of the zero.

The needle is made of aluminium about 10 cm. in length, and at

its broadest parts about 2 cm. in width. The supporting platinum rod terminates in a small half-loop, just below the quadrants. To this loop a very fine platinum wire is attached, supporting a light lead paddle in the sulphuric acid of the glass jar. The quadrants are made of polished brass, the circle of which they are sections having a diameter of 15 cm. They are mounted on glass tubes, made of the best white glass, 5 cm. in height, and 1 cm. in diameter, and mounted on gutta-percha. Through the inside of the tubes run insulated wires imbedded in rubber, connected at the upper end with the quadrants, and at the lower end passing through the brass base plate to binding-screws in the walls of the lower compartment.

One of the quadrants can be slid out, the supporting rod being inserted in a brass plate moving in a groove cut in the base plate. A spring plate with a small projecting knob, fitting into the notches of the base plate, keeps this quadrant perpendicular and firm wherever it may be placed.

The lower compartment is 23 cm. high and 20 cm. square. In it is placed a glass jar of 15 cm. diameter and 10 cm. depth. The vessel is tinfoiled on the outside and bottom, and rests on a circular brass plate which can be either elevated or lowered several inches. The back of the compartment is hinged, and when opened allows full inspection. A platinum wire imbedded in gutta-percha passes through the side of the glass vessel about a centimeter from its upper edge. This wire dips into the acid of the jar.

The instrument, thus constructed, has been in constant use during the past six months, and, requiring but little attention, has proved itself very well adapted for work of this nature.

Multiple Quadrant Electrometer.

With a view to the construction of a portable electrometer sufficiently sensitive and accurate, the following instrument was designed by Professor Trowbridge and Mr. McAdie, and built according to their plans by the Western Electric Company of Boston. An exterior wooden case 30 cm. high and 12 cm. square, contains four compounded quadrants, a compound needle, and the suspending and charging arrangements. The outer case rests on a brass plate with the proper levelling arrangements, and is divided into three compartments, lettered A, B, and C. Each of these has one side at least hinged, so as to open and allow easy access to the interior. At the bottom of the front side of compartment A, a semicircular glass case 2 cm. in height projects. The bottom inside surface of this is mirrored in order to

eliminate errors of parallax in reading the position of a fine aluminium index playing over it. This uppermost compartment contains the suspension apparatus and the long light aluminium index arm. The suspension is as previously described. The aluminium pointer is carried by the platinum wire which supports the needle, but is insulated from it. A small concave mirror is also attached to the platinum wire, so that, if desired, the instrument can be employed with lamp and scale as a reflecting instrument. In the middle compartment B, four brass quadrants are mounted on flint-glass tubes of 4 cm. in length and 1 cm. in diameter. Each quadrant is compounded of four single quadrants. The dividing partitions fit into slots cut in the back plate, and are removable at pleasure. They are held in an exact horizontal position by means of small screws. The needle is made of aluminium, and is also of a compound type, being made of four or more single needles, connected and so arranged as to move between the quadrant sections. The interior surface of compartment B is completely tinfoiled. The third compartment contains a glass jar tinfoiled on the outer side and in connection with the ground. Through the side of the glass vessel is led a platinum wire encased in hard rubber. The deflection of the needle is recorded by the movement of the aluminium pointer. In the instrument constructed, when one set of quadrants is connected with the ground, the other to the positive pole of a Daniell cell, and the needle connected with the positive pole of a Beetz battery of 200 cells (described below), the movement of the index hand is perceptible to the unaided eye. On a scale distant 70 cm. from the mirror this deflection is nearly 2 cm. The length of the suspension is about 4 cm. Increasing the potential of the needle increases the sensibility of the instrument. If, instead of the method generally employed, we connect one set of quadrants with the positive pole of a battery of a number of cells connected in series, and the negative pole to the other set of quadrants and the needle connected with the body whose potential is to be determined, we obtain greater sensitiveness. The deflection obtained has then to be compared directly with the deflection given by a Daniell cell.

Connected in this manner, our electrometer gave a movement of the index hand, for a Daniell cell, of several degrees, or, with the mirror and scale, a deflection of about 4 cm.

For getting a continuous record, this form of electrometer is more easily adaptable than the others. It is also obvious that, aside from the difficulty and uncertainty of photography, an electrometer for successful use in meteorological work must be of such a nature

that its indications may be read at any time or place, and without delay.

Self-recording Apparatus.

We propose to place the following attachment on the multiple quadrant electrometer in order to render it self-recording. A metal plate is placed just above, and a metal cylinder with its axis horizontal just below, the metal index-pointer of the instrument. One terminal of the secondary circuit of a small Ruhmkorff coil is connected to the plate and the other to the cylinder. A strip of co-ordinate paper passing through a solution of iodide of potassium to keep it moist is drawn over the cylinder by clock-work. At regular intervals the primary circuit of the Ruhmkorff coil is broken for an instant by an automatic circuit-breaker, and a spark passes from the plate to the cylinder through the pointer, and registers on the paper the position of the pointer at the instant. Since the induced current will be of short duration, the spark will register the position of the index before the electrifications of the plate and cylinder can influence the needle. In this manner a record of every five minutes, or of every single minute, can be obtained without photography. The instrument need not be placed in a dark room, but may be moved around at will. The cost of the necessary apparatus for this registration will be more, but the expense of running it will be less, than the photographic apparatus. The great advantage of this apparatus will be that single observations can be made at any time without disturbing the record.

The preliminary experiments tried were successful; but as we have been unable to obtain a mechanician who could do the necessary mechanical work properly, the attachment has not been placed on the electrometer.

The Galvanometer.

A galvanometer was used to measure the potential of the atmosphere in the following manner. A condenser was charged by connecting one plate with the collector and the other plate with the ground. The condenser was then discharged through a ballistic galvanometer. By comparing the deflection of the needle with the deflection produced when the condenser is charged by a known electromotive force, and then discharged through the galvanometer, the difference of potential between the collector and the ground was obtained in absolute measure.

The Battery.

The needle of the electrometer was charged and kept at a constant potential by being connected to the positive pole of a constant battery, while the negative pole was connected to the ground.

At first, a zinc and copper distilled water battery of two hundred cells was used. The number of cells was afterwards increased to four hundred. The battery was placed in a large covered box to keep out the dust. The zinc used was common commercial zinc, and became coated with an oxide which had to be scraped off every two weeks. The evaporation of the water in a warm room was very great, so that the battery required constant care.

At the suggestion of Professor Trowbridge, we made a Beetz solid battery.* The cells consisted of glass tubes 10 cm. long and 1.2 cm. in diameter. One half of the tube was filled with white alabaster plaster of Paris mixed with a solution of copper sulphate. A copper wire was placed in this, and the plaster allowed to harden. Then the other half of the tube was filled with plaster of Paris mixed with a solution of zinc sulphate. A zinc wire was placed in this, and the plaster allowed to harden. The cells were connected in series. In order to save the time and trouble required to solder the copper of each cell to the zinc of the next, sheets of copper 10 cm. wide were soldered to similar sheets of zinc. These were then cut into strips, which were bent in the shape of a U. The copper end was placed in the plaster of Paris containing copper sulphate, and the zinc end in the plaster of Paris and zinc sulphate of the next cell. Care was taken that the wires should not extend quite to the middle of the cell, to prevent their coming in contact with the opposite sulphate. The ends of the cells and the connecting wires were dipped in paraffine to prevent the zinc and copper sulphates creeping along the wires. A battery of two hundred cells was made and placed in a box 60 cm. long, 40 cm. wide, and 20 cm. deep, which could be moved around easily. Care should be taken not to connect the terminals, for the battery will polarize and soon destroy itself. Six cells were experimented upon in November, 1884, to determine their electromotive force and internal resistance. They worked perfectly until the latter part of February, 1885, when they gave out. Their average electromotive force was 1.06 volts; their average internal resistance, 1,600 ohms. The rest of the battery does not seem to

* Phil. Mag., March, 1884.

have deteriorated any, although it has been in constant use since November 15, 1884.

An extra cell was made whose electromotive force was 1.04 volts. It has been tested occasionally since, and found to remain constant.

A distilled water cell was completely covered with paraffine. Although it has remained nearly constant, some of the water has been lost, and the zinc is now coated with a thick deposit.

At the same time these cells were made, we made another in the following manner. A copper cylinder six centimeters long and one centimeter in diameter was filled with plaster of Paris mixed with a solution of zinc chloride containing a small per cent of sodium chloride. A zinc wire was placed in this, and the plaster allowed to dry. This cell has an electromotive force of .80 volt, and an internal resistance much less than a Beetz cell. It has remained constant up to date.

A Beetz battery can be made of compact size, and imbedded in paraffine or some solid insulating substance, and made portable so as to be used in connection with a portable electrometer.

This is decidedly the best kind of a battery to use in electrostatic measurements. It has the advantage over the water battery of being cheaper, of being smaller and more convenient to move, and it requires little attention after it is made.

The Collector.

The water-dropping collector proposed and used by Sir William Thomson * was employed at first. It consists of an insulated metallic vessel filled with water and connected to the electrometer. Water drops from the nozzle of the vessel, and reduces it to the potential of the air at the point where the stream ceases to be continuous.

A more convenient arrangement of the same principle is to allow the water to drop first on an insulated metallic plate connected with the electrometer, and then to the ground. The vessel containing the water need not be metallic nor insulated. Water dropping from the plate reduces it to the potential of the air, in the same manner that the nozzle of the vessel was reduced. The metal plate used was of brass 10 cm. by 15 cm. It was placed from five to ten centimeters below the nozzle. Different-sized plates of copper and of brass were used without appreciably affecting the results. With zinc and other plates there was a slight contact electricity between the plate and the brass quadrants of the electrometer. The plate has the double

* Papers on Elect. and Mag., § 262.

advantage over the metallic vessel of being more convenient to arrange and more easily insulated when the humidity of the air is high. The electricity produced by the impact of the water upon the plate is too slight to be measured.

Mechanical Collector.

Continuous records cannot be obtained in this climate with the water-dropper, because in winter water will freeze before it has been dropping long. At the suggestion of Professor Trowbridge several mechanical collectors were tested to see if any could be found that would be superior to the water-dropper.

1. The first consisted of a wheel thirty centimeters in diameter, with strips of tinfoil fastened to its circumference in such a manner that when the wheel revolved on a horizontal axis the pieces of tinfoil touched successively two metal knobs, A and B. A was connected to the electrometer, and B to the ground. When the wheel revolved, each strip of tinfoil carried off a part of the charge of A, and discharged it to the ground through B. Now A, losing continuously a part of its original charge, would approximate nearer and nearer to the potential of the surrounding air.

2. The second consisted of a pendulum attached to a framework. A non-conducting fibre with a metal ball at its lower end passed up through a hole in the framework and was attached to the bob of the pendulum. A piece of metal, G, connected to the ground, was placed in such a position that, when the pendulum hung vertically, the ball rested lightly on G. Another piece of metal, E, connected to the electrometer, was so placed that, when the pendulum swung to either side, the ball touched E. When the pendulum was in motion, the action was the same as in the first experiment. The proper facilities were not at hand for carrying out these experiments to the best advantage, so that the results were not satisfactory. With the apparatus used, the electricity produced by friction was too great to be neglected.

3. Fine platinum wires were attached at equal intervals to the dial-plate of a minute clock, in such a manner that the seconds hand could strike them. The clockwork was of sufficient strength not to be stopped when the hand came against a wire. Each alternate wire was connected to the ground. The others were connected to a metallic plate in the air, and to the electrometer. The seconds hand was insulated from each set. The principle is the same as in the first and second examples.

4. We next made use of the principle, that, if a metallic sphere is carried out in the air and connected by a fine wire to the ground, and then insulated, it will have the potential of the air.* Two wires connected together were placed on the dial of the clock described above, and carefully insulated from the clockwork. They were connected to a metal plate in the air, and to the electrometer. The hands of the clock were connected to the ground. The clock was placed inside of a box lined with tinfoil and hung upon the wall of the room. The tinfoil was connected to the ground. In this way the clock was shielded from the influence of the electricity of the room, and also from the effects of the weather without. A rubber hose ending in a glass tube was placed near the plate, and air drawn in over the plate through the hose by an aspirator. By this means the air around the plate was continually renewed. When the clock was running, the plate was connected to the ground every half-minute for a moment, and then insulated, and therefore took the potential of the adjacent air. When the plate was connected to the ground, the needle would tend to swing toward the zero, but the plate being immediately insulated, the needle would return to the proper deflection. The needle used had sufficient inertia to prevent much swinging. There was only a slight oscillation. In using this collector, if the inertia of the needle is small, the clock can be stopped long enough to take an observation after it has once been in operation and connected the plate to the ground.

With all these collectors, including the water-dropper, we do not measure the difference of potential between the ground and the air, but between the ground and some combination of the ground and air. If the ground is zero, the results will be correct; but if the ground has a local charge, the results will be a combination. For instance, when the mechanical collector is grounded, it takes the potential of the ground. Being then insulated, it combines this potential with the potential of the air, and the electrometer measures the difference between the ground and this combination. In the case of the water-dropper, water is drawn from the pipes in contact with the ground, so that the electrometer measures the difference between the potential of the ground and the combination formed by the charge of the water and the charge of the air. It is probable that this effect is generally very small, and is soon neutralized; but under certain circumstances, (e. g. when an electrified cloud is near the place of observation,) it

* Maxwell's Elect. and Mag., sect. 221.

may be of sufficient magnitude to destroy the value of the observation. In a continuous record, we could not compare the results when this effect was acting with those when it was not acting, and deduce any valuable laws. It was thought that by connecting the positive pole of the battery to one set of quadrants, and the negative pole to the other set, and then connected first to the ground and then to the collector, (the deflection of the needle being noted in each case,) the effect of a local charge in the ground could be eliminated. This was tried with very good results, but it would not be accurate if rapid changes were taking place at the time of observation, nor could it be used to obtain a continuous record.

In order, therefore, to overcome the various difficulties of the collectors described, we made use of the following principle.

Maxwell * says: "Now let us suppose a firm insulated wire carried from the electrode of the electrometer to the place where the potential is to be measured. Let the sphere be first completely discharged. This may be done by putting it into the inside of a vessel of the same metal which nearly surrounds it, and making it touch the vessel. Now let the sphere thus discharged be carried to the end of the wire and made to touch it. Since the sphere is not electrified, it will be at the potential of the air at the place. If the electrode wire is at the same potential, it will not be affected by the contact; but if the electrode is at a different potential, it will by contact with the sphere be made nearer to that of the air than it was before. By a succession of such operations, the sphere being alternately discharged and made to touch the electrode, the potential of the electrode will continually approach that of the air at the given point."

We applied this principle to experiment 2 by making G a metal cup, but the height the ball was raised was so small that we abandoned that method, and constructed the following collector, which seems to be free from all the greater objections. It consists of a framework supporting a brass cup. A non-conducting string with a brass sphere at one end passes through a system of pulleys. A brass plate is attached to the framework just above the cup. It is insulated from the framework by a thick layer of paraffine. The cup is connected to the ground, and the plate to the electrometer. By means of the string the sphere can be made to touch the inside of the cup and the plate successively, and thus reduce the plate to the potential of the air.

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* Elect. and Mag., sect. 221.

The sphere can be raised and lowered by means of clockwork, an electric motor, or a water motor. The laboratory has a small water motor, which was used for this purpose by attaching an arm to the circumference of the wheel and fastening the end of the string to this arm. When the arm is in a certain position of its revolution, the sphere rests lightly on the bottom of the cup. When the arm has turned 180° from this position the sphere touches the plate.

The sphere, cup, and plate must be of the same metal. As the quadrants of the electrometer are of brass, we made these of brass to avoid all contact electricity.

Comparative observations have been made with this collector and the water-dropper for a month. The changes seem to be similar, but the deflections of the water-dropper are the larger.

It seems possible, with some mechanical improvements, to make this form of collector superior to any other.

Observations.

The observations show that—

The potential of the air was generally low and positive, seldom as high as 25 or 30 volts.

The potential usually fell before precipitation, storms, or when the relative humidity increased.

The potential during precipitation, with a very few exceptions, was always low and positive.

Almost all the negative electricity, except that which was followed by precipitation, occurred during west to northwest gales, or during cold waves.

Low clouds sometimes seemed to affect the observations, but high clouds seemed to have no influence.

There was very slight variation with altitude,—at least, between two and ten meters above the ground.

There was no appreciable variation between collectors placed on different sides of the building.

On Obtaining the Electric Potential of the Upper Air.

On the morning of May 6th, the potential of the air at a point ten feet above the ground and three feet from the walls of the laboratory, obtained by the usual water-dropping method, was, reduced to volts, 0.5. A paper kite covered with cloth and tinfoil, with its longest axis about four feet, was flown, the connecting string being heavy English

twine, previously soaked in a mixture of glycerine and water. The end of this string was connected to a wire well insulated, which in turn was connected to one set of the quadrants of the Trowbridge electrometer, the other set of quadrants being connected with the ground. The needle was connected to the positive pole of a Beetz solid battery of 200 cells (200 volts). The needle was at once deflected to its limit, indicating a high positive potential for the air at an elevation of less than 300 feet. Remaining for a few seconds at this high positive, it would suddenly change to an equally high negative, sometimes without the least warning. It was, without doubt, extremely variable. The high positive indications seemed to be more prevalent. Connecting the kite-string with the multiple quadrant electrometer, described in this paper, the following results were obtained. The connection and charge of the needle were as in the other instrument. A fine index-pointer records the deflections in this instrument, and the mirror, scale, and dark room are dispensed with. A Daniell cell gives a deflection of half a degree. The deflection given by the kite was at times over 25 degrees in a positive direction, or equivalent to over 100 volts. The index-hand was seldom still, as in the previous case evidencing an extreme variableness of the electrical condition of the air at that place and time. The wind was from the east, steady and light, the pressure 30.061, the temperature 49° F., the relative humidity 77, and the sky covered with a low pallium of stratus clouds moving from the east slowly.

On the next day, May 7, the kite was again flown, this time reaching an altitude of about 500 feet. The potential of the air at a point ten feet from the ground, obtained by a water-dropper, reduced to volts, was 0.4.

The table on the following page shows the deflections for short intervals. These deflections were comparatively steady, and had not the variableness of those on the preceding day. The wind was east, and had now been blowing from that quarter for nearly thirty hours. The sky was covered with stratus clouds, having the unusual appearance of billows with the crests pointing to the earth. The pressure was 30.040, the temperature 45° F., the relative humidity 75.

The experiment demonstrates that it is comparatively easy to obtain some indication, even if it be only a relative one, of the potential of the air at high altitudes. The method is simple and direct, and with the exception of the original cost of electrometer and charging battery, quite inexpensive. A series of simultaneous observations of this character would doubtless be of value in meteorology.

TABLE OF DEFLECTIONS.

Time. May 7.	Deflection.	Deflection reduced to Volts.	Wind	Remarks.
h. m. s.				
12 0 0 M.	12.0	24.0	E.N.E.	
12 5 0 P. M	+12.5	25.0	E.N.E.	
12 5 30 "	+11.5	23.0	E.N.E.	
12 5 45 "	+12.0	24.0	E.	
12 6 0 "	+10.7	21.5	E.	
12 6 15 "	{ + 9.5 / +11.5 }	{ 19.0 / 23.0 }	E.	Kite diving.
12 6 30 "	+11.5	23.0	E.	
12 6 45 "	+ 9.5	19.0	E.	
12 7 0 "	+ 9.5	19.0	E.	
12 7 15 "	+ 9.75	19.5	E.	
12 7 30 "	+10.0	20.0	E.	Gust of wind.
12 7 45 "	+ 9.5	19.0	E.	
12 8 0 "	+10.0	20.0	E.	
12 8 15 "	+10.5	21.0	E.	
12 8 30 "	+10.5	21.0	E.	
12 8 45 "	+10 5	21.0	E.	
12 9 0 "	+11.0	22.0	E.	
12 9 15 "	+11.5	23.0	E.	
12 9 30 "	+12.0	24.0	E.	
12 9 45 "	+11.75	23.5	E.	
12 10 0 "	+12.0	24.0	E.	
12 25 0 "	11.25	22.5	E.	
12 26 0 "	10.0	20.0	E.	
12 26 5 "	10.0	20.0	E.	
12 26 10 "	10.0	20.0	E.	
12 26 15 "	11.5	23.0	E.	
12 26 20 "	10.75	21.5	E.	
12 26 25 "	11.0	22.0	E.	
12 26 30 "	11.5	23.0	E.	
12 26 35 "	11.0	22.0	E.	
12 26 40 "	11.25	22.5	E.	
12 26 45 "	11.25	22.5	E.	
12 26 50 "	11.0	22.0	E.	
12 26 55 "	11.25	22.5	E.	
12 27 0 "	11.75	23.5	E.	

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